GREENLYNE

Home to Wealth™

FINTECH IN HOUSING FINANCE

FHFA RFI Response

FinTech in Housing Finance: FHFA RFI

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PROLOGUE

GreenLyne and its parent organization Sentrana Inc. are pleased to respond to the FHFA RFI on FinTech in Housing Finance. We are grateful for the privilege to submit our insights, recommendations, and concerns to FHFA and applaud the agency's thoughtful preparation of vital questions to shape this dialog. The RFI itself demonstrates meticulous research and insights that FHFA's Office of Innovation has already amassed on not just the rapidly evolving landscape of financial technology, but on the persistent industry problems those technologies might solve as well as the new concerns and opportunities they beget.

Over the last 5 years, GreenLyne and Sentrana have been in the vanguard of solving some of the most elusive deficiencies that have plagued credit finance. We believe these deficiencies converge to a single long-standing challenge that sounds the highest calling in our industry: a finance system that has failed to safely maximize inclusiveness, with widespread housing inequities as evidenced by an ever-widening homeownership gap between underserved demographic groups and their well-served counterparts.

As a fintech innovator, GreenLyne has taken direct aim at this most crucial call for restoring the American Dream of homeownership across all demographic segments. Our answers to each of the questions articulated in the FHFA RFI are framed by GreenLyne's quest to answer this call. We look forward to continuing this dialog with FHFA and with our fellow colleagues – competitors and collaborators alike – that inhabit the mortgage ecosystem.

A. FINTECH & INNOVATION

1. *How do primary and secondary mortgage market participants define fintech in the housing finance sector? What key factors should be considered?*

   GreenLyne defines fintech in the housing finance sector as any innovation that transforms heretofore manually performed tasks into computationally performed tasks executed via software. For example, if Identity Verification & Management was previously performed via manually conducted phone-calls and paperwork review, and this particular task can now be performed computationally via Blockchain-based identity authentication, then the bundle of computational capabilities that fulfills this task is deemed financial technology.

   GreenLyne asserts that "financial technology" or "fintech" should not be conflated with "automation". Even if a task is not automated, but the human actor that is involved in the execution of that task is augmented by computational support, we deem that support mechanism as financial technology. For example, if the human actor is augmented with technology that helps them with manual identify verification, but that manual labor is supported with assistive capability that computationally reads a mortgage applicant's signature and compares it with signatures that are on-file to generate a match-score in milliseconds, we deem that assistive capability as financial technology. We define three factors for characterizing financial technology:

   a. **Human "*In the Loop*":** Human actors are the primary performer of the task but are augmented by assistive technology.[1]

   b. **Human "*On the Loop*":** The computational system is the primary performer of the task, and the human actor evaluates the proper and fair functioning of that computational system's results.

   c. **Human "*Off the Loop*":** The computational system is both the primary performer of the task, and the system also evaluates whether the task was performed properly and fairly. Financial

[1] Stuart E. Middleton, S.E. et al. "Trust, Regulation, and Human-in-the-Loop AI", *Communications of the ACM,* April 2022.

technology can be any form of computational execution of a task in which a human actor is "in the loop", "on the loop" or "off the loop".

2. *How could FHFA facilitate adoption of "responsible innovation"?*

"Responsible innovation" hinges on enabling technological advances that improve the stability, safeness, liquidity, and equity of the housing finance to emerge at maximum speed and minimal cost, while ensuring risks are ***contained*** to the fullest extent. Innovation inherently depends on experimentation, and experiments can fail or yield unintended and unpredicted outcomes. FHFA can facilitate experimentation and the adoption of responsible innovation in two ways:

a. **Foster a Loosely Coupled, Highly Modularized Mortgage Finance Ecosystem:** The mortgage ecosystem consists of many interconnected parts, which creates a fertile ecosystem for brittleness, failure, or unforeseen harm that occurs in one part of the system will propagate across the entire system and toxically impact many other parts or de-stabilize the system as a whole. This is a serious risk in the current housing finance landscape because the existing system and its parts do not reflect the principle of "loose coupling, high modularity".

In a loosely coupled system, each part is carefully enclosed and isolated from other parts so that failures are quarantined. For example, in an automobile the transmission is loosely coupled with the engine - they are not intricately interwoven. If the transmission overheats or if a gear within the transmission fails, it will not result in a cascade of failures that causes the engine to fail, then the brakes to fail and eventually the entire car to fail. But the current housing finance system is a highly coupled, lowly cohesive system. Every part is interwoven with every other part.

If there are inequities in the risk scoring of households, those inequities propagate into inequities in loan pricing, which then propagate as failures in liquidity in the secondary market due to inaccurate and inequitable assessments of risk of a secondary market bond.

We believe that if FHFA can decouple the various parts of the housing finance system so that there is some independence across nodes in the mortgage value chain – i.e., risk scoring (i.e., FICO) can be divorced from loan pricing (which again hinges on FICO) can be divorced from risk rating a mortgage backed security (which still hinges on FICO) – so that each of these nodes can function independently without using the same common factor, then FHFA will be able to set the stage for responsible innovation.

Individual parts can be innovated to improve the deficiencies of that one part, while risks and failures and unintended harm (such as inequity) becomes contained to that one part.

One way to de-couple highly interwoven systems is to introduce a new component in between existing components that allows risks, harms, and contagions to be contained or isolated. For instance, in the mortgage underwriting-to-pricing workstream (both of which depend on FICO), a new component that GreenLyne refers to as *Equitable Second-Look underwriting* can be inserted. When FICO-based underwriting creates inequitable outcomes for credit invisibles or thin-credit households (and a lost safe-and-sound revenue opportunity for lenders), then the second-look engine can employ a different scoring mechanism and loan pricing mechanism (perhaps one based on cash-flow underwriting) to underwrite and price denied borrowers.

This new "second-look" node in the value chain can allow VantageScore or RIKI Score (or some other scoring mechanism that is fairer and more equitable and is capable of seeing the full credit strength of a borrower) to help optimize the combination of loan size and loan APR that will generate the risk-adjusted target rate of return and profits that the GSE desires while minimizing the disparate impact ratio of loan approvals.

The key message here is that rather spending years debating whether VantageScore or RIKI Score or some other score should replace the current central beam that traverses the entire end-to-end structure the mortgage finance industry (i.e., FICO), FHFA can introduce modularization of the whole structure by introducing new nodes into the structure such as a "second-look for underwriting

and pricing" node, and allowing lenders to select from a roster of competing "second look engines" based on whichever maximizes fairness for the borrower.

b. **Establish "Clinical Trial" Testbeds:** Just as the FDA has established a bounded and narrowly contained testbed for clinical trials in which a new drug is trialed across a very closely monitored cohort before the drug is introduced into the broader population, FHFA can setup testbed environment where new financial innovations can be "clinically trialed" and the efficacy and toxicity of the innovation can be meticulously measured, monitored, extrapolated for long term consequences prior to being introduced across the entire population. GreenLyne and its parent company Sentrana Inc. have participated in the design of clinical trial approaches that have enabled dramatic acceleration of drug discovery for underserved diseases.

   A well-designed "clinical trial" type of environment setup by FHFA could allow new credit scoring variables, such as VantageScore 4.0+ or RIKI Score from FormFree, to be deployed in a testbed population for underwriting. The subsequent loan pricing and securitization that depends on this new score should also be performed in this clinical trial testbed. FHFA can provide a backstop safety net that traps consumer harm before the harm reaches the consumer if the experiments in the testbed fail. The consumer population can be kept small for this testbed environment, but large enough to glean statistically valid conclusions. Given the annual multi trillion-dollar mortgage finance industry, GreenLyne calculates less than 0.001% of the market would be needed to populate a statistically significant mortgage finance clinical-trial testbed.

3. *What factors currently inhibit the adoption of fintech and innovation in the primary and secondary housing finance sector? Are there specific challenges related to privacy laws, industry standards, or current practices?*

   GreenLyne observes that a significant inhibitor of adoption of fintech and innovation in the primary and secondary housing finance sector is the vertical integration deeply enmeshed this sector. The central beam running through this vertical integration is the FICO score – that singular score determines underwriting approval, loan pricing, loan securitization, mortgage insurance.

   Due to the monopolistic nature of this central beam on which the entire housing finance structure is built, it is prohibitively expensive to modularize different parts of mortgage manufacturing and drive incremental innovation within an isolated part without requiring the whole system to change. Note, the concern we are expressing here is not that FICO is antiquated (which it is), or that FICO is discriminatory (which it is), or that it is an imprecise predictor of credit risk (which it is), or that it is a highly uncertain measure of financial strength (which it is).

   Rather, the primary concern we are expressing here is that a single score has been established as a monopolistic central beam for vertically integrating the entire end-to-end mortgage lifecycle. If a fully modernized score that transcends all the shortcomings of FICO were to be installed in lieu of FICO as the new singular central beam to which all loan underwriting, pricing and securitization activities were anchored, we would express the same concern: singular central beams that vertically integrate the mortgage manufacturing chain pose significant inhibitions to innovation, equity, consumer recourse, and the agility of FHFA and the GSEs to adapt to constantly changing socioeconomic dynamics.

   Without undermining the stability of the entire system, we encourage FHFA to enable innovation by permitting alternative data, alternative scoring, and alternative pricing approaches that provably (via back-testing) deliver equal or greater predictive accuracy of the risk-adjusted Net Present Value of borrowers to coexist with current approaches and allow lenders to select whichever approach minimizes disparate impact and maximizes fairness & equity on an individual borrower basis.

   In short, we encourage FHFA to advocate for replacing the fixed and discriminatory Loan Level Price Adjustment (LLPA) grid with adaptive technology that provides dynamic and personalized loan configurations. Doing this would enable FHFA to help financial technologists surmount two of the most salient impediments that have undermined innovation and equitable mortgage finance:

   a. **Impediments due to a Tightly Interwoven Mortgage Ecosystem:** The entire mortgage lifecycle is tightly coupled with deeply interwoven parts throughout the entire ecosystem, all of which is

underpinned by an antiquated and biased FICO risk-scoring model. Consumers cannot be underwritten with alternative risk scoring models because the downstream loan pricing utilizes FICO, and the further downstream securitization also utilizes FICO. This makes it nearly impossible for technologists to introduce impactful and equitable innovations into the system simply because altering in one part of the system requires the entire system to change. The analogy here would be the vertically integrated manufacturing trusts we witnessed in the early 20th century that hampered consumer choice and suffocated innovation, for which the Clayton Antitrust Act of 1914 was established.

b. **Impediments due to a Serial Mortgage Origination Workflow:** A serial workflow of the mortgage lifecycle leads to suboptimal outcomes for consumers and a hampered ability to innovate for technologists. For instance, loan underwriting and loan pricing are performed serially where the approval of the loan occurs first then the rate determination occurs second, instead of the workflow occurring in a parallel fashion where loan officers attempt to simultaneously optimize the loan size and the loan APR to find an ideal loan configuration that will maximize affordability for the borrower and the risk-adjusted Net Present Value of that loan for the lender.

   For example, a borrower may be denied a $300,000 mortgage at 7.4% APR because it would be unaffordable for the borrower and the risk-adjusted profit for the GSE would not clear a target rate of return. However, a $220,000 mortgage at 8.1% APR for a home purchased at 0.78 LTV would result in an affordable mortgage for the borrower and clear the risk-adjusted target rate of return hurdle for the GSE. This is a multi-objective optimization problem that today is being performed in a serial workflow with labor-intensive trial and error conducted by loan officers.

   For first time homebuyers that are seeking smaller sized loans, the costs of loan origination are already high compared to the revenue the lender can achieve on that loan. The appetite for labor-intensive serial trial-and-error is low and the ability for technologists to introduce innovations that can remedy the labor-intensity is hampered by the serial workflow imposed by the GSE's due to how current AUS and Product Pricing Engines are invoked serially. This serial workflow between AUS and PPE prevents fintech innovators from delivering easy-to-use solutions that empower lenders and borrowers to find loan configurations that are optimal for both parties.

B. IDENTIFYING FINTECH OPPORTUNITIES IN THE HOUSING FINANCE ECOSYSTEM

1. *What kind of fintech activities have the greatest potential to positively impact the housing finance sector? Describe several situations in which a product or service has been or could be used, the factors considered in determining importance, and associated impacts.*

   Despite the massive sums spent on fintech initiatives within the housing finance sector over the past seven years, production-related expenses have continued their inexorable climb, laying clear the reality that these investments did little to change the dependency on human effort for critical portions of the scaling function, which in turn have caused further disparate impacts to proliferate between underserved groups and well-served populations.

   The housing finance sector is fraught with significant disparate impacts that materialize throughout the end-to-end mortgage lifecycle. Fintech activities that address these disparate impacts directly have the greatest potential to unlock a vast reservoir of mortgage-ready, underserved households - most of whom are Black or Hispanic and have been ensnared in a persistent racial homeownership gap. Consider the following insights GreenLyne has gleaned from publicly available HMDA Data:

	Guild Mortgage	Movement Mortgage	Rocket Mortgage	PenFed Credit Union	Mr. Cooper	JPM Chase	Wells Fargo
Ratio of White Originations to Black Originations	9.9x	6.7x	8.5x	7.1x	7.5x	14.4x	15.5x
Ratio of White Applicants to Black Applicants	8.7x	6.1x	7.5x	7.4x	7.0x	13.9x	13.4x
Ratio of White Households to Black Households*	4.9x	4.9x	4.9x	4.9x	4.9x	4.9x	4.9x
Disparity in White vs. Black Mortgage Originations	202%	137%	173%	145%	153%	294%	316%
Disparity in White vs. Black Mortgage Applicants	178%	124%	153%	151%	143%	284%	273%
Spread in White vs. Black Disparities of Applicants and Originations (basis points)	24	12	20	-6	10	10	43

* See: https://www.statista.com/statistics/242027/number-of-households-in-the-us-by-ethnic-group/

For some of the largest mortgagers in the U.S. the ratio of loan applicants between White and Black households is as high as 14 to 1. Yet the ratio of White to Black households is only 5 to 1. There is a 284% disparity at the top of the mortgage value chain in terms of the number of applicants across racial groups entering the mortgage process. At the bottom of the value chain, the disparities get even worse in terms of the ratio of White to Black applicants that are approved for a mortgage, approaching almost 320% of disparity (even after adjusting for the 5 to 1 ratio of White to Black households across the population as a whole). GreenLyne has anchored its innovation thrusts on three workstreams to promote a more efficient, equitable, and sustainable-growth housing finance system:

a. **Second Look Combinatorial Loan Configuration Optimization:** Fintech activities that provide an alternative, fair lending optimized "second look" at denied applicants after they enter the mortgage lifecycle so that the true and full credit strength of the applicant (which reflects not just their FICO but their bank cash-flow data) is utilized to predict an approvable optimal loan configuration (i.e., the ***combination*** of loan size and loan APR).

b. **Equitable Pre-Look Loan Optimized Cross-Selling:** The number of mortgage-ready, overlooked households in the U.S. market that have self-selected themselves out from seeking a mortgage has been estimated by Harvard's Joint Center for Housing Research to fall somewhere between 3.3 million to 6 million households[2]. The majority of these households are from communities of color, where inequities of homeownership have endured across generations. The deeply held fear within these households that they will invariably be denied housing finance creates a self-limiting choke, with the net result that they do not even attempt to apply for a mortgage. However, buried within bank transaction data, apartment rental data, neobank debit card data, and so forth are prolific data-driven signals that unveil the mortgage-readiness of these households. Financial technologists should endeavor to continuously extract these signals and equip banking institutions and independent mortgage banks with insight on personalized and optimized qualifying mortgage loan configurations (loan size + loan APR + home LTV) that should be proactively marketed by banks and neobanks to underserved customers that either do not yet have a mortgage or struggle to obtain cash-out refinancing of their existing mortgages.

c. **Proactive Loss Aversion:** Speed of mortgage servicing is particularly essential when a mortgaged household encounters financial duress. Loan modifications must be made expeditiously with financial relief or loan forbearance provided for that household. This servicing support is provided post-hoc after a household has experienced a string of delinquencies and harm to the household's credit record has already occurred. Preventative loss mitigation support that can be provided ex ante to the household's delinquent payments can positively impact the housing finance system. The data, algorithms, and computational power now exists to predict impending financial distress, which should trigger mortgage servicing outreach to proactively mitigate loss. Credit risk models that fail to take into consideration month–over-month macroeconomic variables, consumer cash-flow variables will fail to anticipate the household's financial distress in a timely

[2] Perkins, K. et al. "The Potential for Shared Equity and Other Forms of Down Payment Assistance to Expand Access to Homeownership", *Harvard Joint Center for Housing Studies*, October 2019.

manner and will inevitably process loan forbearance actions after much harm has occurred to the household's credit footing.

2. *What are the typical time requirements of each process within the mortgage lifecycle? What are the "critical path" activities that drive the mortgage timeline and borrower expense? How could fintech be applied to improve efficiency, reduce costs, reduce time requirements, or facilitate equitable outcomes for borrowers?*

   Focusing on "***typical*** [emphasis added] time requirements" can obscure the inequities of the mortgage lifecycle, where large, marginalized populations that have been unserved by the housing finance system are deemed atypical. The time requirements for the mortgage lifecycle follows a wide bell curve. On the left-side of the bell curve, the mortgage lifecycle timeline can be quite short for certain applicants. On the right-side of the bell curve, the timeline can be onerously protracted for a different cohort of applicants. Eighty percent (80%) of applicants fall within one standard deviation of the middle of this bell curve.

   To address the inequities of the mortgage lifecycle, we should focus on the atypical time requirements that occur beyond one-standard deviation to the right from the average time requirements, where thin-credit or credit-invisible applicants are predominantly situated. The time and costs required to execute the mortgage lifecycle for this cohort is large, yet loan revenue is minimal on this end of the bell curve. There are no incentives for loan officers to spend additional time to explore alternative loan configurations where an optimal combination of loan size + home LTV + Loan APR can be found to produce an approvable qualifying mortgage for a borrower that otherwise would be denied given their initial request.

   For borrowers that fall in the upper 80th percentile of labor and time required to execute their mortgage lifecycle, the iterative "what-if" simulation that loan officers must perform to find an optimal loan configuration that will be viable for this borrower is a critical path activity for driving equitable homeownership, yet the labor-intensity and low return on time investment for the loan officer prevents this activity from occurring. Financial technology geared around expansive individual applicant-level combinatorial optimization techniques to find the loan configuration sweet spot for underserved borrowers can dramatically improve efficiency, reduce costs, reduce time requirements, and facilitate equitable outcomes for borrowers.

3. *What are the typical drivers of repetitive requests to borrowers or reevaluation of underwriting information by the lender in the mortgage process, and what opportunities exist to automate processes?*

   Given the substantial homeownership gaps that exist between underserved mortgage-ready credit invisible or thin-credit households versus credit-visible borrowers, we believes that addressing the typical drivers of inefficiency will improve outcomes for demographic groups that are already served by the housing finance system, but will not ameliorate the atypical factors that undermine the underserved and disenfranchised populations that have either failed to achieve homeownership or are afraid of rejection in the path to homeownership.

   GreenLyne has found that a significant atypical driver of inefficiency occurs with borrowers that fail to qualify for a mortgage. This cohort requires highly iterative, labor-intensive exploration and "what-if" simulation by loan officers to find the right loan size and loan price along with the right LTV that will enable a borrower that is initially declined to become approved. GreenLyne has reduced the labor, time, cost, and risk of this combinatorial optimization process. To ensure the utmost fairness and equity in this loan configuration optimization process for underserved borrowers, GreenLyne incorporates the full financial strength of the applicant into models that predict the risk-adjusted expected Net Present Value of the applicant. This requires us to use not only credit bureau data such as FICO but the borrowers bank cash-flow data such as RIKI from FormFree or VantageScore 4.0+ or even raw bank aggregation data from providers such as Pentadata or Yodlee. This data must be integrated with the normalized data emerging within the GSEs from fintech providers such as Cielway Inc.

4. *What are the existing data challenges that most prevent data-driven decision-making in the mortgage lifecycle?*

   Over the last 5 years of Research & Development effort in developing fair lending loan price and loan configuration optimization algorithms, GreenLyne has seen the emergence of robust data sets that remediate past data challenges, which can now adequately satisfy the voracious appetite for data that these algorithmic advances require. We believe that earlier data challenges have been dramatically reduced with the advent of consumer-level bank cash-flow data and newer consumer risk scores such as VantageScore 4.0+ or FormFree RIKI Score.

   For training the fair lending algorithms to achieve maximum fairness, one thorny data deficiency still remains. Models are trained on data to achieve high predictive performance on loan default probability and prepayment probability. One way to assess the quality of the model is by examining how well it predicts the default and non-default across a historical data set of households. But since these historical datasets only contain households that were previously approved to receive a mortgage, the datasets do not reflect how households that were previously denied mortgages would have performed on their debt. As such, the quality of predictive mortgage Net Present Value models cannot be gauged in terms of "how much money a lender is leaving on the table" when it incorrectly declines a mortgage to a borrower.

   To rectify this deficiency in existing data sets, we suggest the GSE's begin cultivating a dataset that reflects loan approval experiments. Experiments can be developed that would randomly originate mortgages to households that are actually denied by the Automated Underwriting Systems so that a repository of long-term data can begin to be compiled concerning the payback performance of borrowers that are denied. Given the $4+ trillion mortgage finance industry, GreenLyne estimates that less than 0.01% of denied mortgages would need to be experimentally approved in order to establish this critical dataset for training future fair lending algorithms.

5. *What are the existing regulatory and policy barriers to adopting and implementing fintech within the mortgage lifecycle?*

   a. **Collaborative Mortgage Origination & Servicing:** With the advent of neobanks, who have visibility into the deposit transactions of households, a new opportunity exists for the neobanks to determine which households might be mortgage-ready despite being credit-invisible or thin-credit. The neobanks could proactively market personalized and optimal loan configurations to these households and route the household to a downstream Independent Mortgage Bank or to a nationally chartered bank to originate and service the mortgage. However, such a multi-party transaction is laden with friction due to numerous regulations such as FCRA, GLBA, and RESPA. While these regulations have substantial protective benefits, they have the unintended consequence of preventing proactive outreach from the emerging category of digital banks like Kinly, Chime, Varo, etc. (whose customer base is disproportionately underserved households) to first time homebuyers who do not realize they are capable of obtaining a mortgage and therefore do not even attempt to apply for a mortgage. To close the homeownership gap, this cohort of households requires proactive marketing of personally optimized mortgage offers, but the friction introduced by certain Regulations thwarts such proactive collaborative marketing involving multiple disparate enterprises across the banking and lending value chain.

   b. **Shared Equity Down Payment Assistance:** This is emerging as a financial innovation that can facilitate significant expansion of homeownership across underserved and minority first time homebuyer markets, but regulatory challenges confront this financial innovation from achieving large scale liquidity. Namely, SEC Regulation Exception A Tier 1 and Tier 2 rules limit the amount of funding that can be raised for shared equity Down Payment Assistance securities, require each security issuance to be qualified by the SEC and there are no investor protections that provide a backstop on potential losses that can befall a purchaser of these securities.

   c. **Equitable Integration of Mortgage Finance & CRA Obligations:** Current CRA regulations are structured around underserved census tracts, rather than underserved demographic groups - namely Black and Hispanic households regardless of the census tract in which they reside. The

homeownership gaps that exist are rooted not only in marginalized census tracts, but in marginalized demographic groups. Banks that originate non-QM mortgages into underserved census tracts can accrue CRA credit, and if there is no default on the given mortgages within a certain period of time, these mortgages become QM and can be sold to the GSEs. But the current CRA regulations do not enable lenders to acquire CRA credit for mortgages and investments made to marginalized and underserved households that reside outside of the CRA census tracts, which limits the adoption of fintech innovations such as Shared Equity Down Payment Assistance across a much broader swath of underserved households.

C. Equitable Access to Mortgage Credit

1. *What new fintech tools and techniques are emerging that could further equitable access to mortgage credit and sustainable homeownership? Which offer the most promise? What risks do the new technologies present?*

   a. **Household Mortgage Readiness Self-Awareness Tools:** Underserved minority households that have been on the sidelines of housing finance are operating with a severe knowledge deficit of their own financial worth and risk-adjusted Net Present Value profit potential to mortgage lenders. The relationship between their credit score (such as FICO) and their forecasted profit potential to a lender is unknown to these households. These households are operating under the mistaken belief that they have greater loss potential instead of profit potential, and therefore will be rejected by mortgage lenders.

   GreenLyne is keen on putting this knowledge directly at the fingertips of individuals. LMI and minority households can finally see themselves as profit-generating assets rather than loss-inducing liabilities for lenders. By giving these households precise insight on their accurate risk-adjusted profit potential to a lender, they can gain both the self-confidence to apply for a mortgage and gain insight on the precise mortgage configuration in terms of loan size, loan APR, and home LTV that is optimal for them.

   For example, GreenLyne's precision-guided technology might show a first-time homebuyer household that even after adjusting for their default and prepayment risks, they could be approved for a 30-year $300,000 mortgage at 7% APR and that their risk-adjusted Net Present Value is $392,000. When a marginalized household learns that their risk-adjusted profit potential to a lender is worth more than the capital they are seeking, it profoundly shifts the agency of marginalized households to self-select themselves into the housing finance process.

   The risk presented by this set of new technologies are:

      i. The models that shed insight on a household's risk-adjusted profit potential to a lender are inaccurate and thereby provide misleading guidance to the household

      ii. The tools (and algorithms) used by households to better understand their own financial worth and profit potential to lenders are divergent from the tools (and algorithms) used by lenders to determine the net present value of a given borrower. Tools and algorithms that forecast a borrower's Net Present Value should be certified by the GSE so that insights that a borrower gleans for themselves via these tools are comparable to the insights that a lender gleans for a given borrower.

   b. **Shared Equity Down Payment Assistance (DPA):** Data shows that more than 6 million renters in the U.S. can safely and soundly afford a monthly mortgage to a property in the same census tract in which they are currently renting for equal or greater square footage of living space but are unable to afford the $25,000 to $100,000 down payment required to obtain a mortgage[3].

   Tools are emerging where in exchange for a shared equity stake in the property, the homebuyer receives down payment assistance for up to 17% of the property value, which represents an 85%

[3] See Footnote 2.

share of the equity in the home. These shared equity ownership stakes represent a new asset class.

This new asset class is illiquid and must be held until the owner sells the property or refinances the property. Due to the illiquidity of this asset class, there are two risks that GreenLyne believes FHFA should be attuned to:

i. One source of risk is the homeowner's probability of defaulting on the mortgage, which will trigger foreclosure proceedings and property sale at below market rates

ii. The other source of risk is subpar appreciation rate of property value

Both of these risks must be precisely and accurately predicted for every homeowner-property pair in order for shared equity DPA markets to function efficiently. GreenLyne's high precision, fair lending predictive algorithmic advances make such accurate predictions possible.

Even with the advent of GreenLyne's algorithms, there still remains a risk of liquidity for this new asset class because there currently is no secondary market in which these asset classes can be traded. There is no insurance market that protects investors in this asset class from losing their investment capital in the case of black swan events that lead to high property depreciation.

Although GreenLyne can supply the algorithms to underwrite such insurance policies, market participants are needed to provide the insurance. FHFA can play a pivotal role in catalyzing the emergence of such market participant.

We foresee newer tools emerging from GreenLyne's algorithmic innovations that will enable a pool of shared equity DPA assets across multiple properties to be securitized, fractionalized, tokenized, and fractional tokens sold to both accredited and unaccredited investors under the auspices of SEC Regulation Exception A+ Tier 1 Rule[4,5]. While this has the potential to introduce significant liquidity into the Down Payment Assistance market, which in turn will help underserved households obtain mortgage financing by reducing their LTV and the potential for small investors to participate in fractional homeownership, the risk is that SEC Regulation A+ combined with shared equity DPA can result in financial losses for unsophisticated retail investors. To protect against this harm, we encourage FHFA to explore institutional mechanisms whereby the GSEs could serve as a guarantor that protects against complete capital losses of fractionally owned shared equity DPA assets just as today they are guarantors of qualified mortgages.

c. **Equitable Full Financial Strength Scoring:** GreenLyne harnesses fair lending optimized default risk prediction and loan price optimization algorithms combined with panoramic financial data of a borrower to predict the precise, equitable, risk-adjusted Net Present Value forecasts of a borrower. GreenLyne uses this precise risk-adjusted borrower-level NPV prediction to determine the optimal interest rate suited for that borrower to maximize loan affordability and loan profitability. The risks with these technologies are as follows:

i. Fair lending optimization algorithms often require a conscious trade-off between improving the bias of a model versus reducing the accuracy of a model. Policymakers may fail to determine the best trade-off point or adequately justify their selection of a trade-off point (how much accuracy should be forfeited to make how much improvement on bias).

ii. Fair lending optimization algorithms are computationally demanding and in order to harness the full power of these optimization algorithms, lenders will need to harness the full power of available computational infrastructure. Since most organizations are designed with modelers and data scientists operating independently of IT infrastructure engineers,

[4] Knight, J. et al. "FAQs about Regulation A+ Securities Offerings", *Bass Berry Sims Report*. See here: https://bit.ly/3VxRNEq.

[5] Securities and Exchange Commission. "Amendments for Small and Additional Issues Exemptions under the Securities Act (Regulation A)", 17 CFR Parts 200, 230, 232, 239, 240, 249, and 260. June 2015. See here: https://bit.ly/3g8J777.

there is a risk that fair lending optimization algorithms will deliver sub-optimal results due to limited use of available compute power.

iii. In order to feed a wider spectrum of financial data (such as a consumer's bank cash-flow data) into fair lending optimization algorithms, the consumer must provide explicit consent for institutions to access this private data. There is a risk that institutions may fail to adequately explain the value of this data, the purpose for its retrieval, the various outputs that will be generated from this data, the consumer's recourse to explain mistakes that may be present in this new spectrum of data, and so forth.

d. **AI Combinatorial Optimization:** The default risk and prepayment risks of a borrower change with the size of loan, the price of the loan, the debt-to-income ratio of the borrower, and the home loan to value ratio. As any of these factors change, the resulting risks change. Furthermore, the quantitative link between these factors and the specific risks of a given borrower is not a static relationship. The sensitivity between these factors and predicted risks changes as macroeconomic conditions change. While underwriting systems and loan pricing engines remain sequentially independent from each other, the burden falls on loan officers to find the right combination loan size and loan price that will be an ideal fit for a given borrower's specific predicted risks. This burden is exceptionally heavy and vulnerable to the loan officer's ability to see the hidden interconnections of how moving loan size up or down in conjunction with moving loan price up or down will affect the borrower's ability to qualify for a mortgage while receiving a rate that will simultaneously maximize affordability and profitability. GreenLyne has developed Fair Lending optimized artificial intelligence techniques that can quickly discover these hidden interconnections and find the combination of loan parameters that will jointly maximize lender profits and borrower affordability. The risks of such AI Combinatorial Optimization tools are:

i. Loan officers may defer too much of their human reasoning to the tool, and thereby forfeit the power of human imagination to find creative loan configurations that might best fit the highly nuanced and unique circumstances of a given borrower.

ii. AI Combinatorial Optimization tools benefit from an abundance of training data. Large lenders that have a large repository of diverse loan configurations that have been historically originated will have an advantage in deploying more insightful AI Combinatorial Optimization capabilities.

iii. AI Combinatorial Optimization tools must interact with Product Pricing Engines (PPE), Automated Underwriting Systems, Property Appraisal Systems (PAS's), Next Generation Credit Risk Scoring Engines (CRS). Although the number of AUS's might be limited (Desktop Underwriter and Loan Product Advisor), we anticipate a diversity of PPE, PAS, and CRS solutions to proliferate in the market. AI Combinatorial Optimization tools have the risk of integration failure into a lender if the tool is not designed to communicate with that lender's specific PPE, PAS, or CRS componentry.

e. **Personalized Fair Lending Loan Configurator:** GreenLyne combines the Equitable Full Financial Strength Scoring and AI Combinatorial Optimization technologies into a unified framework that can be incorporated into a mortgage lender's workflow. This technology provides real-time intelligence to loan officers and borrowers regarding the viable range of loan configurations that are safe and affordable for the borrower irrespective of their degree of credit invisibility.

Personalized Fair Lending Loan Configurator engines run the risk of having slow upgrade cycles because they are tightly coupled with adjacent systems, and any upgrade to the configurator can have unforeseen deleterious ripple effects on the adjacent systems, and vice versa. Although Personalized Fair Lending Loan Configurators represent a significant innovative leap, their ability to undergo continuous rapid innovation that relentlessly increases consumer benefit is at risk as a result of being a central linchpin in the mortgage origination lifecycle.

f. **Equitable Second Look Engines (ESL):** GreenLyne's second look engine operates at the tail-end of existing Automated Underwriting Systems. When a borrower is declined a mortgage by the AUS, the declined borrower's application and all associated data is routed to the ESL engine to

see if personalized loan configurations associated with a lender's Special Purpose Credit Program (SPCP) can be identified that will result in an affordable and profitable Qualifying Mortgage for that borrower. The risk with ESL engines is that while they may yield a qualifying mortgage for a borrower, the range of loan configurations might be so tight (in terms of loan size and home LTV) that the homebuyer is unable to find any properties that fit within the approved loan configuration window.

g. **Equitable Pre-Look Cross-Sell Engines (EPL):** GreenLyne's pre-look engine operates at the tip of Automated Underwriting Systems. A large number of marginalized, overlooked, and underserved households that are mortgage-ready but credit-invisible (or credit-thin) do not pursue mortgages because they fear rejection and do not realize they are mortgage ready. They do not know their financial worth to a lender, and banks do not know that there's a mortgage-ready customer hidden within the bank's portfolio of deposit accounts. GreenLyne's Equitable Pre-Look (EPL) engine unveils this reservoir of invisible mortgage-ready households and proactively markets a personalized optimal loan configuration to the household. The risk of EPL engines is that while banks can mine their own deposit accounts for mortgage-ready households, Independent Mortgage Banks (IMBs) such as Rocket Mortgage or Guild Mortgage do not have mineable accounts and the large underserved market that so far has been untapped by lenders may continue to remain cloaked and out of reach for the largest group of mortgage originators (i.e., the IMBs).

h. **Proactive Loss Aversion (PLA) Engines:** GreenLyne's proactive loss aversion engine employs state of the art, fair lending optimized dynamic predictive models that preemptively identify borrowers that are at imminent heightened risk of loan delinquency due to current macroeconomic signals and/or borrower's bank cash-flow signals. These engines determine optimal loan reconfigurations or customized loan forbearance recommendations and trigger cueing to the mortgage servicer to provide proactive loan adjustments to avert loss and hardship.

2. *What emerging techniques are available to facilitate or evaluate fintech compliance with fair lending laws? What documentation, archiving, and explainability requirements are needed to monitor compliance and to facilitate understanding of algorithmic decision-making?*

The housing finance industry is at an inflection point in the evolution of key technologies that can not only facilitate compliance with fair lending laws, but significantly improve the fairness and equity of activities throughout the mortgage lifecycle. Advances in high performance computing have made petaflop computing (one quadrillion computations per second) easily available in the cloud.

These computing advances have been flanked by algorithmic advances for search a vast space of diverse credit scoring and loan pricing models to find less discriminatory alternatives, while also producing models that are highly interpretable (i.e., non-black box models) and capable of expressing their own uncertainty. Computational horsepower, and the expensiveness thereof, have historically blockaded such fair lending optimizations, which in turn hindered the evolution of algorithms capable of delivering large fair lending gains. With immense computational power now ubiquitously available, powerful fair lending optimization algorithms and techniques can be marshaled at scale.

GreenLyne has been in the vanguard of integrating state of the art advances across some of the most powerful techniques that have emerged for driving fair lending credit decisioning and fair lending compliance, which include:

a. **Combinatorial Genetic Optimization** for discovering less discriminatory combinations of predictor variables

b. **Bayesian Optimization** for discovering less discriminatory configuration settings for risk prediction and loan pricing models (such configuration settings are often referred to as hyperparameters)

c. **Gaussian Process and Hierarchical Bayesian** algorithms for generating predictive models that are aware of their own uncertainty of predictions

d. **Symbolic Regression** algorithms for generating predictive models transparent "clear boxes" that are readily interpretable and whose predictions are inherently explainable

e. **Adversarial De-Biasing** algorithms for discovering less discriminatory alternative models

3. *Are there effective ways to identify and reduce the risk of discrimination, whether during development, validation, revision, and/or use fintech models or algorithms? Please provide examples if available.*

Powerful algorithms to identify and reduce the risk of discrimination have emerged. All of these methods make use of metrics that are able to quantify discrimination. GreenLyne reduces the risk of discrimination by explicitly encoding metrics that measure discrimination directly into the algorithms used through the mortgage finance workflow. Since discrimination measurement inherently requires the use of protected class variables as part of the algorithms, this technical design may contrast with the mandates of ECOA and Reg B regulations. GreenLyne has written a comprehensive Special Purpose Credit Program plan to govern the safe and equitable deployment of its fair lending algorithms. GreenLyne's explicit integration of discrimination metrics directly into credit decisioning algorithms is applied during the development, validation, revision, and operational execution of activities in the mortgage lifecycle.

Two of the most important metrics for measuring discrimination are Adverse Impact Ratio (e.g., the ratio in the rate of Black loan approvals to White loan approvals) and Standard Mean Difference (e.g., the difference in the average interest rate offered to White borrowers minus the average interest rate offered to Black borrowers divided by the standard deviation of White interest rates) - referred to as AIR and SMD, respectively.

At the specific points in the mortgage lifecycle where GreenLyne technology is employed, the technology operates as a radar gun capable of detecting violations at scale. It autonomously monitors the inputs and outputs of a given activity in the mortgage workflow and assesses discrimination by calculating AIR and SMD for that activity.

For example, mortgage marketing activities (which induces some population of the consumer market to apply for a mortgage or for a refinance) will result in an AIR of potential disparities in Black to White applicants. The mortgage configuration and underwriting activities will result in an AIR that measures disparities in Black to White originations. The mortgage pricing activities will result in an SMD measuring disparities in Black to White differences in average APRs. The mortgage underwriting activities will result in an SMD measuring Black to White differences in the forecasted average default and prepayment rates.

GreenLyne technology fits into multiple nodes across the mortgage lifecycle. The GreenLyne discrimination-monitoring algorithms (such as Genetic Optimizers, Adversarial De-Biasers, Symbolic Regressors, etc. – see response to C.2) enable different nodes in the mortgage lifecycle to be continuously assessed and can update AIR and SMD dashboards as well as drive alerts that trigger human action. Each node in the lifecycle can be augmented with discrimination remediation engines that are embedded with fair lending algorithms to reduce the risk of discrimination.

D. IDENTIFYING & MITIGATING FINTECH RISK

1. *What risks do fintech and fintech firms present to the economy and the financial sector? To the housing finance sector? To FHFA-regulated entities? To counterparties of FHFA-regulated entities and other third parties? To mortgage borrowers and consumers?*

GreenLyne has historically observed three types of risk that can either harm consumers or destabilize the housing finance system:

a. Unforeseen *interaction effects* between two seemingly distant parts of the mortgage ecosystem

b. *Lag effects* where the consequences of an action are delayed

c. Inequity effects where harm or lack of inclusion is unevenly distributed across demographic groups.

As financial technology diversifies and proliferates across the mortgage ecosystem, the threat of unforeseen interaction effects and lag effects will increase. The threat of inequity risks will increase due to the very nature of technological progress, which is to achieve economies of scale - i.e., technology innovation attempts to address the most *typical* deficiencies, the most *typical* points of friction, and the most *typical* detractors to profitability.

By focusing on achieving economies of scale, which means focusing on the most typical problems, fintech innovations run the risk of overlooking the atypical problems that remain hidden because they are associated with underserved demographics. The housing finance system runs the risk of not having enough incentives to drive technological innovation that benefits those who do not currently appear as the large-scale cohort in the mortgage ecosystem – i.e., those that fall within the homeownership gap.

FHFA runs the risk that fintech companies will push the envelope on achieving great economies of scale on activities and practices that are already in place for the well-served borrower base but will fail to push the envelope on achieving extraordinary *economies of scope* on serving diverse populations. This creates a vicious negative self-reinforcing cycle that can result in amplifying adverse interaction effects or lag effects that undermine already-underserved populations.

GreenLyne encourages FHFA to not define use-cases in terms of "typical" needs, and instead embrace nomenclature that jives with a statistical distribution of variegated needs.

2. *What risk management practices do industry participants use to address the risks posed by fintech and innovation in housing finance?*

   GreenLyne's R&D and technology deployment explicitly incorporate the measurement of fairness and discrimination in its engineering activities and takes a "systems thinking" approach that maps out interaction effects, lag effects, and inequity effects[6,7]. GreenLyne quantifies metrics for measuring bias and disparate impact and turns these metrics into explicit variables that are integrated into quality control tests. For example, multiple models that have equivalent high accuracy can often be derived from a given historical training dataset, but each of those models will have varying levels of disparate impact and bias.

   GreenLyne, and its parent company Sentrana Inc., have implemented a comprehensive scaffold of tests that shed light on not just the single objective of predictive accuracy, but the dual objective of predictive accuracy and disparate impact. The sophisticated milieux of tests performed by GreenLyne and Sentrana to uncover discriminatory risks, profitability risks, affordability risks, lag effect risks, and adverse interaction effect risks are chronicled in publicly disclosed fair lending reports of one of the largest fintech lenders in the U.S. (Upstart Corporation) for whom Sentrana (employing GreenLyne advanced fair lending technology) has been appointed as a risk monitor.[8]

   In addition to the aforementioned risks, we note that all models have uncertainty and even the quality metrics and accuracy metrics of a model are themselves uncertain. Before models are put into production, GreenLyne not only assesses their accuracy and disparate impact, but also quantifies the uncertainty of the model using mathematical advances that are specifically geared for uncertainty assessment (such as Gaussian Process modeling, or Bayesian modeling, etc.).

3. *What particular risks to consumer privacy have been associated with fintech? What practices are being used to manage these risks?*

   Large scale consumer bank data aggregation organizations such as Pentadata, Yodlee, FormFree, etc. have emerged with direct access to granular bank transaction data for almost all households in the U.S. that have savings or checking accounts. This data can be accessed in milliseconds through easy-to-

[6] Senge, P. et al. "The Dawn of System Leadership", *Stanford Social Innovation Review*, Winter 2015. See here: https://bit.ly/3rYwcXU.

[7] Bers, J.A. et al. "Accelerated Radical Innovation: Theory and Application", *Technological Forecasting and Social Change*, January 2009. See here: https://bit.ly/3CWzDor.

[8] "*Report: Fair Lending Monitorship of Upstart Network's Lending Model*", published September 16, 2022. See here: https://bit.ly/3rXzkmR.

use APIs, and once the API is invoked, the invoker gains deep visibility into the detailed private financial behavior of any given consumer.

These data aggregator APIs present a single-point-of-security-failure where any individual that may surreptitiously get their hands on the security key required for invoking the API will be able to access unprecedented private financial data. These APIs are unaudited, unregulated, and uncertified. There are laws that protect consumers in that their private financial data cannot be disclosed to third parties without the explicit consent of the consumer.

But the advent of easy-to-use, simple security-token enabled data aggregator APIs has dramatically opened the attack surface through which cyber-criminals can gain access to private data illegally without consumer consent. We encourage FHFA to incentivize experimentation and innovation on how APIs can be securely invoked in ways that radically reduce the possibility for bad actors to hack the APIs. Practices such as multi-factor authentication or blockchain based identity authentication have emerged as noteworthy security-enhancing practices. We encourage FHFA to explore these practices and how they may be brought to bear on API-access to personally sensitive housing finance data.

E. RegTech

1. *What are the most promising areas for applying technology to regulatory and compliance functions? Please describe opportunities for "regtech" to simplify or improve compliance with FHFA, Enterprise, or FHLBank requirements.*

One of the most promising areas for applying technology and modeling advances to regulatory and compliance functions is Fair Lending, with a focus on Reg B and the Equal Credit Opportunity Act (ECOA) compliance. GreenLyne has harnessed the confluence of formidable advances in data, mathematics, and computational power to drive innovations geared towards highly personalized, precise, accurate, and equitable credit scoring & loan pricing technologies that simplify lenders' adherence to Fair Lending compliance.

The key to achieving this improvement in fair lending compliance is incorporating metrics that measure discrimination into every facet of the GreenLyne technology fabric. To fully harness the rich information that is now available across thousands of variables, new mathematical models that can grapple with such wide information have been developed. Although black box mathematical techniques emerged initially in the industry for generating predictive insight out of these wide information sets, GreenLyne's R&D activities have advanced the state-of-the-art for achieving fair lending compliance beyond opaque black box approaches.

Black box techniques can inadvertently encode prohibited proxies for race, gender, and age. Due to their black box nature, those proxies might go undetected. Those techniques can also encode predictive bias and disparate impact across demographic groups, which may also pose difficulty to remediate due to the black box nature of those techniques. Black box techniques also suffer from an inability to disclose the model's inherent uncertainty about its own accuracy and uncertainty about its predictions. Finally, the model's behavior might not be easily interpretable.

In summary, although mathematical techniques have emerged that can increase fairness and equity by reasoning with a wider assortment of data variables, these techniques must comply with the fair lending safeguards inherent in ECOA and Reg B. Such compliance requires identifying and remediating (1) prohibited proxies, (2) disparate impact & bias, (3) uncertainty, and (4) interpretability. Technological advances that reduce the time, cost, labor, and error of evaluating models against these four crucial facets of fairness and safety that stem from ECOA are amongst the most needed and the most promising applications of RegTech innovation.

Special Purpose Credit Programs offer a powerful avenue for addressing systemic biases in the housing finance ecosystem by allowing protected class variables to be embedded directly within algorithms so they can directly measure their own level of discrimination. GreenLyne has implemented an SPCP written plan that allows us to dramatically improve the speed and scope of Fair Lending testing, and thereby improve the efficiency of achieving regulatory compliance with ECOA and Reg B.

F. STAKEHOLDER ENGAGEMENT

1. *What forms of stakeholder engagement are most effective in facilitating open, timely, and continuous discussion on the challenges and opportunities presented by the application of fintech to housing finance?*

   GreenLyne, and its parent company Sentrana Inc., have discovered the best practice of launching "grand challenges" with accompanying non-PII datasets that have been launched by the U.S. Defense & Intelligence agencies have worked particularly well for driving engagement and promoting focus on the key challenges and opportunities presented by rapidly[9]. Examples of these Defense Department "grand challenges" (with accompanying datasets) include the xView Challenge published by the U.S. military's Defense Innovation Unit. Not only have "grand challenges" provided a great foundation for driving stakeholder engagement, but the challenges also accelerated the pace of safe innovation.

2. *What are some topics for a housing finance-focused "tech sprint" and how could FHFA encourage participation?*

   Related to the concept of a "tech sprint", FHFA and the GSEs should provide a test-bed environment in which new technologies that support only one part of the mortgage lifecycle can be tested within the arc of the entire end-to-end lifecycle on a limited population of borrowers. This would allow for true beta-testing in which the test reveals the unintended consequences or ripple effects and risks of a new technological innovation.

   Just as FDA clinical trials are conducted on a limited population, but the full potency and all associated adjuvants of a drug are tested on this limited population, fintech innovators need a limited-population beta test environment in which risks and failures can be tolerated because FHFA is prepared to provide restitution and recourse to the affected small test population.

   Without such a deliberately designed standing beta-test environment and methodology, new innovations can become mired in debate amongst many stakeholders, which limits swift iterative improvement of the innovation and incurs the risk of only identifying potentially harmful consequences of the given innovation if human imagination can foresee the consequence.

   It will be better to perform real-life, but well-contained, experiments with the given innovation to identify harmful effects and consequences that are difficult to predict from human policymaker debates. In summary, one important topic for a housing finance-focused "tech sprint" would be to design the parameters of a test-bed environment, the instruments and dashboards required to monitor beta-tests in that environment, so that new software that is developed as part of a tech sprint can be evaluated with unprecedented holism.

   With respect to specific tech sprints, GreenLyne proposes the following to FHFA:

   a. **Equitable Second Look tech sprint** to rapidly reevaluate a declined mortgage applicant with alternative fair lending optimized credit scoring models combined with alternative data (such as cash-flow data) to generate personalized optimal loan configurations that can be safely approved by the GSEs.

   b. **Equitable Pre-Look tech sprint** to identify individuals that are mortgage-ready but may be credit invisible or credit-thin and generate personalized optimal loan configurations that are proactively marketed to the given individual.

   c. **Proactive Loss Aversion tech sprint** to preemptively identify borrowers that are at imminent heightened risk of loan delinquency based on current macroeconomic factors and/or borrower's bank cash-flow patterns and trigger proactive outreach to the borrower with customized loan forbearance recommendations.

[9] See here: https://www.diu.mil/ai-xview-challenge .

EPILOGUE

The U.S. mortgage industry is a beacon of the global housing finance landscape. It is unrivaled in its sophistication, transparency, and liquidity. These are the very qualities that render it fecund with opportunity to exponentially expand the accessibility of mortgage products – and do so safely and sustainably. Mortgage manufacturing is buffeted by the same rapidly evolving technological forces that are causing tectonic shifts in other manufacturing sectors. Manufacturing processes have become more modularized, replete with more interchangeable parts than ever, more automated with humans "*on the loop*" instead of "*in the loop*", more job growth, more precise, more durable, more quality controlled, and more customer-centric. The manufacture of mortgages is not immune from these same seismic forces that have transformed all other manufacturing sectors. Failure to properly channel these seismic forces will invariably stress the system, resulting in destructive earthquakes. In the mortgage industry, such earthquakes will materialize in the form of wealth destruction. And our underserved communities, who remain marginalized within the rift of persistent homeownership gaps, will be most effected. This rift is not as much a byproduct of high origination costs and *inefficient* loan origination activities, but of *ineffective* design of activities.

According to 2020 Fannie Mae data, the average cost to originate a purchase loan was near $7,000[10]. This cost has steadily increased over-over-year, despite increasing use of technology. It is a false premise that technology will bring cost down. As with all manufacturing processes, when the safety, soundness, and accessibility of a manufacturered product improves, or the speed and mass customization of manufacturing increases, higher costs are involved. We have witnessed this in other manufacturing sectors from cars to smartphones to manufactured homes to airplanes to fast food. The inflation adjusted average cost of a vehicle in 2022 is 735% higher than in 1935 (when the Bureau of Labor Statistics began tracking this cost), despite the formidable technological advances and automation brought into automobile manufacturing [11].

The reason manufacturing costs do not decline in relation to technological progress is because innovation enables the features, performance, safety, and differentiation of manufactured products to grow exponentially. GreenLyne anticipates that with the advent of fintech, the cost of individual tasks in mortgage manufacturing will decrease but the aggregate cost of the fully manufactured product will rise. While technology drives economies of scale that lower the cost of manufacturing, it also drives new product capabilities and features that incur higher cost. This is not a failure of progress, but a hallmark of it.

So, if an increase in aggregate cost is an inevitable correlate of technological progress, how will the rising cost of mortgage manufacturing improve access for already underserved markets? The answer is that while costs will grow linearly, the other barriers impeding accesibility must fall exponentially. FHFA is uniquely positioned to see the holistic barriers that perpetuate housing access inequalities. These barriers include: misperceived credit risk, steep down payment hurdles, inaccurate or unfair property appraisals, onerous loan application processes with daunting documentation requirements, cumbersome exploration of different loan configurations, etc. Technological innovation that diffuses these barriers may introduce marginal cost into the mortgage manufacturing process, but will yield improvements in the value and accessibility of the mortgage product that far outweigh the incremental cost. We encourage FHFA to not evaluate the merits of technological innovation solely through the lens of how those innovations affect manufacturing cost, but through a ratio of accessibility increase divided by cost increase.

Accessibility has been constrained from the era of redlining. Even as redlining ended and ECOA legislated fairness, financial inclusion did not improve due to the rigid internal structure of the mortgage manufacutring factory. This factory, in the form of the GSEs and their automated underwriting & loan pricing systems have enshrined a rigid and tightly coupled approach for risk scoring, loan pricing, and securitization. Such rigidity leads to a highly commoditized and non-differentiated mass manufactured product akin to Henry Ford's Model T, which, as Ford proclaimed, "you can get in any color you want, as long as it's black". The rigid characteristics of QM mortgages results in a highly commoditized product resistant to customer-centric customization. It stifles competitors from innovating the mortgage product because they are unable to pick and choose different credit scoring mechanisms, different loan price optimization or loan configuration optimization mechanisms. Their hands are cuffed, and so they are unable to innovate and speciate in ways

[10] Begley, J. et al. "Mortgage costs as a share of housing costs—placing the cost of credit in broader context", *Fannie Mae Economic and Strategic Research Group Working Paper*, March 2022. See here: https://bit.ly/3rUC4lb.
[11] *U.S. Bureau of Labor Statistics* data. See here: https://bit.ly/3T60fZP.

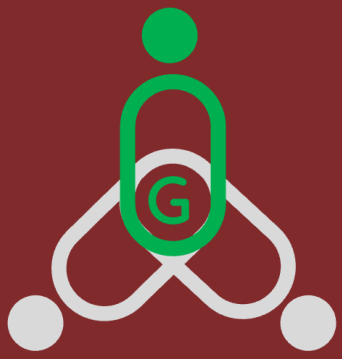
that permit different demographic groups to be served safely and soundly with different mortgage products manufacturered differently.

In contrast to Ford's maxim for uniformity, General Motors' President Alfred Sloan championed "*a car for every purse and purpose*". This unleashed a torrent of innovation *and* inclusion. It exponentially increased the accessibility of automobile ownership in the U.S. throughout the 1920s. Under the banner of Sloan's decree, highly differentiated products emerged that catered to differentiated consumer needs and purchasing power – from Chevrolet to Oldsmobile to Buick to Cadillac. The rigid steel beam of a single monopolistic scoring mechanism that runs through the entire mortgage manufacturing process leads to mass rigidity instead of mass customizability. Lenders have wound up competing against each other with the same commodity product, with no wiggle room to innovate and differentiate. Until this rigidity is dissolved, and the factory floor for manufacturing mortgage products is modernized to be a factory comprised of interchangeable and movable parts, innovation in this industry will remain confined to simply improving efficiency for demographic groups that are already served by housing finance without improving accessibility for groups that been historically underserved.

The strength of our housing finance system and associated mortgage manufacturing process has also become its greatest weakness. All the gears of this manufacturing process have been designed to seamlessly interlock with the precision and complexity of a Patek Philipe Swiss watch. At the outset, the precise interlocking of so many gears may have been optimal and fit-for-purpose when it emerged. But the very precision-crafted seamlessness of these gears make interchangeability and upgrade of any individual gear nearly impossible without years of deliberation, policy review, and engineering paralysis. The issue is not that certain gears have become antiquated and require modernization.

Instead, it is the underlying architecture of the manufacturing plant itself that requires incremental change. Rather than the architecture of a finally crafted Swiss watch, where all the moving parts are inextricably interlocked, an architecture more befitting of the present era of rapid technological innovation and ever-widening demographic segments is needed. Borrowing from best practices learned in other manufacturing industries, GreenLyne believes the architecture of a Personal Computer serves as a more optimal metaphor for the desired housing finance architecture. The internal components of a PC are not seamlessly interlocked, but are designed to interoperate so that individual parts can be replaced and upgraded without requiring changes to the entire PC. From the CPU to the power supply to the graphics card or the hard drive or the memory – every component can be replaced at the speed at which it evolves.

By transforming the mortgage manufacturing "factory" from one that is designed for mass manufacturing to one designed for mass customization and personalization of mortgage products, we can unleash the full innovative and economic potential of all market participants in this industry and finally turn the tide for closing stubborn wealth divides fueled persistent homeownership gaps.



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